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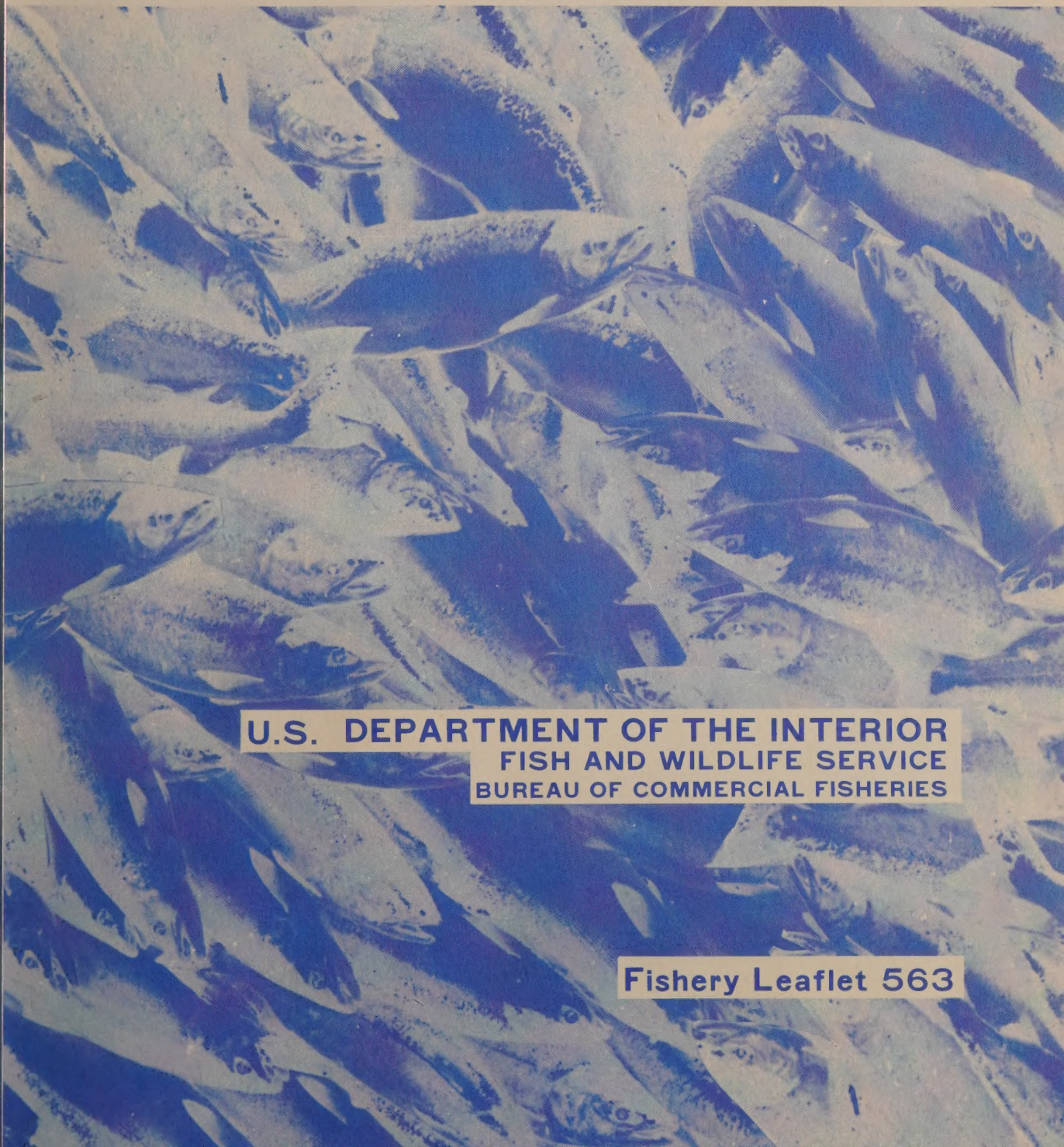
PACIFIC SALMON



U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Fishery Leaflet 563

Created in 1849, the Department of the Interior--a department of conservation--is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States--now and in the future.

Revision of Fishery Leaflet 14 (Issued 1943; revised 1949, 1954, and 1958.)

UNITED STATES DEPARTMENT OF THE INTERIOR
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PACIFIC SALMON

by

Clifford J. Burner

Fishery Leaflet 563

Washington, D.C.

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PACIFIC SALMON

by Clifford J. Burner, Fishery Biologist
Bureau of Commercial Fisheries, Seattle, Wash.

INTRODUCTION

Of all the world's fishes, the Pacific salmon (Oncorhynchus sp.) are perhaps the most exciting. Hatched in streams, rivers and lakes of the mountainous coast of North America and eastern Asia, they journey miles out into the sea. Here they grow to great size before they return to spawn and find waiting nets and hooks of fishermen.

North Pacific waters are the true home of salmon for very good reasons. Along the shores are many cold, fresh-water streams, inviting spawning and protecting the abundant eggs and fry. The North Pacific Ocean into which the fingerling salmon later disappear is an ideal rearing ground because of its cooling Arctic Currents and rich food supply of smaller marine organisms. In only one other part of the world's oceans have Pacific salmon become firmly established. In south New Zealand, where temperatures and other factors have combined ideally to form "salmon water," transplanted, healthy runs of chinook salmon now flourish. In the Great Lakes, a transplanted run of pink salmon is starting to take hold even without access to the sea which salmon normally require to reach their great size.

Five species of salmon swim the waters of the Pacific coast of North America. These are the pink (humpback) salmon, chinook (king) salmon, sockeye (red, Columbia River blueback) salmon, coho (silver) salmon, and the chum (dog) salmon. These are known to scientists by their specific Latin names of O. gorbuscha, O. tshawytscha, O. nerka, O. kisutch, and O. keta. All belong to the genus Oncorhynchus of the family Salmonidae (salmons and trouts). The Atlantic salmon is more closely related to the trouts than to the Pacific salmon.

These five species of Pacific salmon are also found in Siberia, Kamchatka, and Sakhalin. In Japan there is a sixth species of salmon (Oncorhynchus masu). The "masu" and chum salmon occur in commercial quantities in Japan, but masu, because of their small size, are much less valuable than any of the other five species.

GENERAL LIFE HISTORY

All species of Pacific salmon are anadromous, which means that the adults migrate from the ocean into fresh-water streams to spawn. This usually takes place in the summer and autumn, and in the same streams where they began life. How they manage to return to their "home stream" after their sojourn in the sea is still a mystery. The female salmon deposits her eggs in a nest, or redd, which she digs by fanning her tail in the gravel of the stream or shallow lake-shore waters. Digging is alternated with egg-laying followed by fertilization by the male salmon. In this process, the fertilized ova are covered with successive layers of gravel to a depth of several inches.

There is considerable variation in the life cycle of salmon depending upon the species and character of fresh-water habitat. Hatching time for the eggs depends upon water temperature and is usually about 3 months. Newly hatched fish live in the protective gravel of the nest and gradually absorb the food in the abdominal yolk sac (fig. 1). At the end of this time they wriggle up through the gravel and begin the search for food.

The length of time the young stay in fresh water varies. In some species, such as pink salmon, the young begin their migration to the sea immediately. Other species stay in fresh water for as long as 3 years. Once they reach the rich feeding grounds of the ocean, they remain there from 1 to 4 years, growing rapidly. As they approach sexual maturity in the sea, they return to fresh water to spawn and thereby complete the cycle. Pink salmon have the shortest cycle of all, which is always 2 years. Sockeye and chinook salmon have the longest cycle and may require up to 8 years to reach maturity, although they usually need 4 to 6 years.

While Atlantic salmon (Salmo salar) and its Pacific coast relative the steelhead trout (S. gairdneri) may spawn more than once, all Pacific salmon die after spawning.

Several items of comparative data for the five species of Pacific salmon are given in table 1.

FOOD

Each species of salmon has its food preferences, which change somewhat during growth and development. Young salmon feed on plankton organisms, which are the myriad small, nearly invisible plants and animals that swarm in fresh and salt water. Pink, sockeye, and chum salmon throughout their existence feed mostly on plankton, including some larger squid and shrimps. Chinook and silver salmon subsist largely on insects and small fishes during their early life in fresh water. When they are in the ocean, they feed on herring and other small fishes, as well as some of the larger plankton creatures. With a few individual exceptions, no Pacific salmon feed after entering fresh water on their spawning migration. They strike at the sport fisherman's lure apparently from force of habit.

MIGRATION

Most Pacific salmon return as adults to the same stream from which they migrated to the ocean as fingerlings. If young salmon are transplanted from one river to another, they return as adults to the stream in which they were planted and not to the one from which the eggs came. Eggs of Alaska salmon have been shipped to the Columbia River where they were hatched, reared, and released. At the age of about 18 months the young migrated to the ocean, where they remained 2 or 3 years and then returned to the Columbia River. Marking experiments have shown that there is only slight straying from the home stream. Consequently in regulating the salmon fishery, the population in each river system must be considered a unit and given adequate protection to avoid depletion.

Pink salmon are unique among Pacific salmon in that they have marked and consistent differences in abundance in odd- and even-numbered years. This condition existed before the start of the commercial fishery, and its cause is unknown. Its continuation is a natural accompaniment of the unvarying age at maturity and the strong homing instinct of this species. In the Puget Sound area, millions of pink salmon appear in odd-numbered years, but the

runs in even years number only a few thousand. In Alaska, no consistent variation appears in the runs from year to year. Throughout Siberia, heavy runs appear in even-numbered years and very light ones in odd years, although in the southern part of the district (Tartar Strait) considerable numbers of pink salmon do appear in odd-numbered years.

IMPORTANCE

Because of their very palatable quality and their fighting character, salmon are invaluable as both commercial and game fish. They are taken by trollers and purse seiners and by reef nets and gill nets in coastal waters, and principally by gill nets in larger rivers. The flesh of salmon is rich in proteins, fats, and vitamins, and makes an excellent canned product. Although large quantities are sold fresh, frozen, pickled, and smoked, the bulk of the commercial catch is canned. In fact, salmon canning is the greatest fish canning operation in the world.

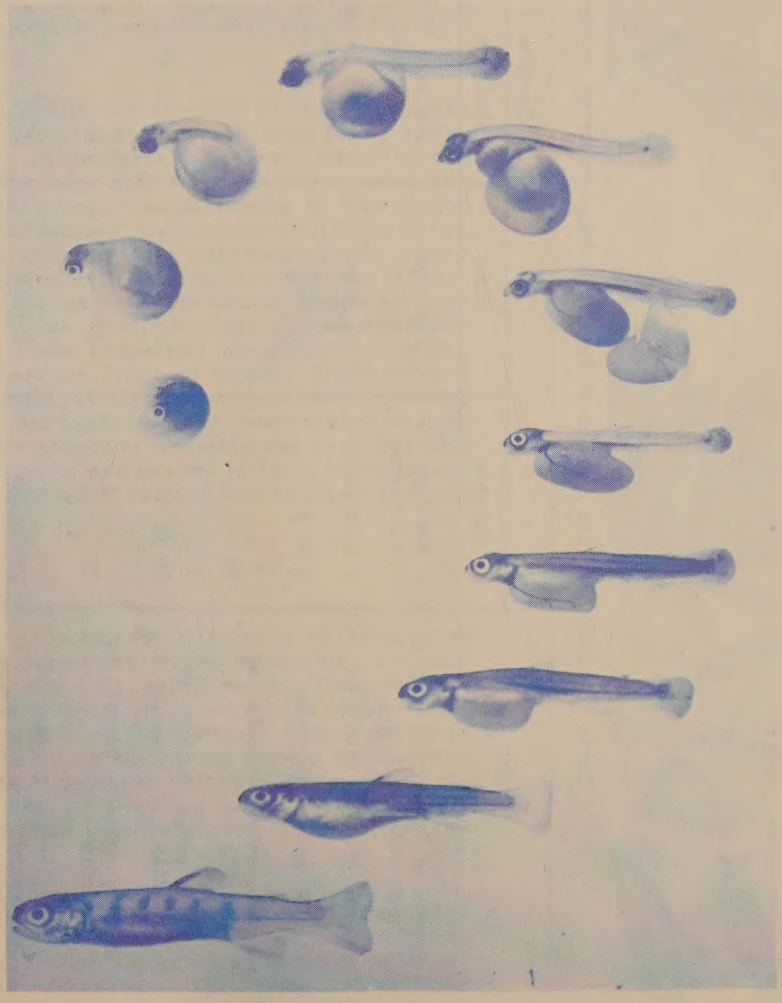

Figure 1.--Stages in the development of a salmon: eyed-egg to free-swimming fry. (Approximate normal size.)

Table 1.--Data for five species of Pacific salmon occurring on West Coast of North America

Item	Species				
	Chinook	Pink	Sockeye	Silver	Chum
Length of time young stay in fresh water	few days to 2 years	few days	few days to 3 years	1 to 2 years	few days
Length of ocean life	1 to 5 years	$1\frac{1}{3}$ years	$\frac{1}{2}$ to 4 years	1 to 2 years	$\frac{1}{2}$ to 4 years
Life at maturity, years	2 to 8	2	3 to 7	2 to 4	2 to 5
Length, average inches, at maturity	36	20	25	24	25
Length, range, inches, at maturity	16 to 60	14 to 30	15 to 33	17 to 36	17 to 38
Weight, average, pounds, at maturity	22	4	6	10	9
Weight, range, pounds, at maturity	$2\frac{1}{2}$ to 125	2 to 9	$1\frac{1}{2}$ to 10	3 to 30	3 to 45
Principal spawning months	Aug.-Sept.	July-Sept.	July-Sept.	Sept.-Dec.	Sept.-Nov.
Fecundity-number of eggs	5,000	2,000	4,000	3,500	3,000

Salmon provide outdoor recreation for fishermen of all ages. Chinook and silver salmon are especially prized by sportsmen. Other salmon species seldom take artificial bait or lures of the sportsmen because of their feeding preference for plankton-size organisms. Anglers troll, spin, and cast for salmon in the ocean, in coastal bays, and in rivers and creeks--in fact, everywhere that adult salmon are found and where angling is permitted. While some immature salmon are taken in streams, by trout fishermen and in the sea by sport fishermen, most are caught as adults on their spawning migration from salt into fresh water.

PROBLEMS

Salmon have very specific fresh-water requirements. A subtle physiological change is triggered by fresh water which stimulates the final maturation of eggs and sperm. If it is fresh water other than that of the "home stream," maturation may be blocked or stopped. The spawning migration, spawning act, hatching of eggs and rearing, and migration of young all require adequate flows of pure cold water and clean gravel of proper size in water of proper depths and velocities.

Almost everything man does spoils one or more of these essential water qualities, with the end result that each year sees fewer areas left for salmon production. Agricultural uses of water lessen stream flows. Frequently the return flows from farm lands are warm, silt-laden, and contain chemicals poisonous to fish and to organisms which serve as food for fish; unscreened irrigation channels divert small fish from streams into cultivated fields where they die; logging destroys watersheds; mining may destroy stream beds, cover them with silt, or release poisonous materials into the water. Industries and cities dump industrial and domestic wastes into the rivers, and some industrial uses increase water temperatures beyond the tolerance limit of fishes. Flood control and power projects upset normal patterns of flow, inundate spawning areas, and present obstacles for upstream and downstream migration of fish. Even highway construction projects can have harmful effects, for example when creeks are passed under a highway and care is not taken to assure that adult salmon can swim up through the pipe or tunnel.

RESEARCH ON SALMON

Because they are a choice, protein-rich source of food, considerable research is being done to solve the numerous problems associated with perpetuating and increasing salmon runs. Salmon hatchery operations are the subject of research to improve all phases from holding and spawning of mature fish right up to determining when and at what size the young should be released into the river. These studies encompass hatchery diets, nutrition, and control of disease as well as genetics to improve the breed by developing salmon stocks that mature faster and return to the fishery earlier.

Intensive research is being directed at the many problems associated with upstream and downstream passage of fish at dams. Formerly the upstream passage of salmon was thought to be the principal problem because it was assumed that young fish on their downstream migration could simply go over the spillways. In recent years research has demonstrated that successful downstream passage is the greater problem because the young fish

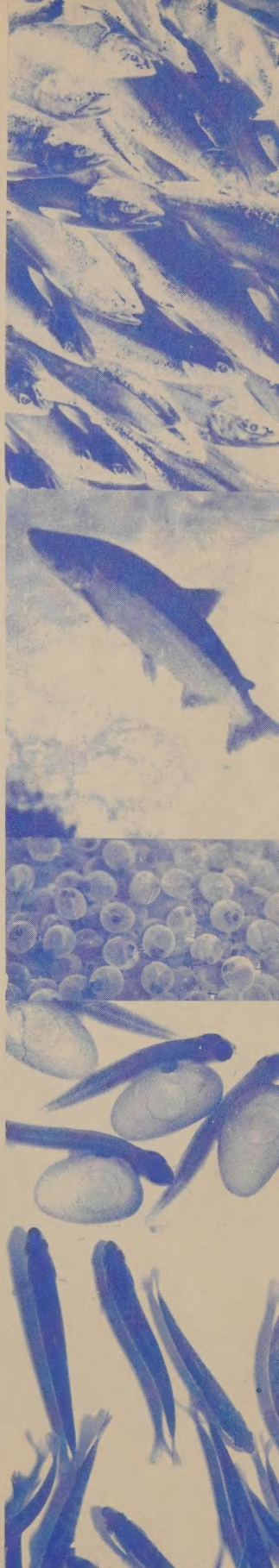

Table 2.--Commercial catch of salmon in Pacific Coast States, 1950-60

[In thousands of pounds]

Year	Pink		Chinook		Sockeye		Silver		Chum	
	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska
1950	45	85,728	24,361	12,198	8,879	82,597	17,753	22,472	12,687	61,924
1951	33,978	113,666	27,410	15,791	8,264	57,917	15,784	36,280	12,199	52,934
1952	10	79,511	26,091	14,706	8,600	101,547	22,506	21,898	12,099	65,305
1953	34,493	62,677	24,918	14,261	12,589	70,759	14,433	14,239	6,225	58,340
1954	2	88,692	24,207	12,208	35,269	56,467	9,056	22,581	9,149	67,084
1955	31,683	96,496	31,142	11,642	6,558	51,028	12,212	16,505	4,610	28,004
1956	5	102,151	28,997	9,161	6,617	87,631	16,373	13,346	2,359	57,609
1957	17,569	54,083	20,234	10,275	9,111	58,400	12,294	14,450	2,508	66,229
1958	23	120,698	16,593	10,990	33,125	34,687	10,211	13,116	6,247	61,764
1959	13,693	48,047	15,694	11,720	10,400	43,390	8,353	11,852	6,266	32,269
1960	11	52,577	14,945	9,112	7,161	88,165	4,114	9,551	2,116	47,695

Table 3.--Value of commercial catch of salmon in Pacific Coast States, 1950-60

[In thousands of dollars]

Year	Pink		Chinook		Sockeye		Silver		Chum	
	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska	Wash., Oreg. & Calif.	Alaska
1950	6	6,767	6,061	2,268	2,292	6,985	4,466	2,685	1,988	3,932
1951	5,097	13,137	7,452	3,037	2,535	6,712	3,423	5,104	1,633	4,378
1952	1	7,502	6,475	3,349	2,438	11,962	3,903	3,116	1,404	5,091
1953	3,999	5,196	5,919	2,719	3,359	8,311	2,417	1,538	614	3,734
1954	([1])	7,908	6,658	2,325	9,986	7,061	1,755	2,552	952	4,751
1955	4,599	8,568	9,284	2,308	1,925	6,592	2,615	2,260	666	1,887
1956	1	9,256	9,505	1,849	2,224	13,043	4,342	1,770	396	3,834
1957	2,479	5,881	6,340	2,202	2,788	9,505	2,672	2,112	326	5,336
1958	4	11,055	6,009	3,025	9,252	6,338	2,975	2,222	816	4,207
1959	2,106	4,921	5,931	3,002	3,256	8,275	2,373	2,370	1,118	2,389
1960	2	6,815	6,765	2,558	2,341	18,093	1,595	2,190	471	3,900

[1] Less than 500 dollars.

may not find the outlets from the reservoir, but, even more important, may not find their way down through the reservoir. Because there is some indication that adult salmon also have difficulty in passing up through reservoirs, much attention is being given to this problem.

Improvement of the natural habitat, abatement of pollution, control of flooding, and laddering of falls and dams have achieved considerable progress in restoring depleted runs. Fish farms where small salmon are reared under natural feeding conditions closer to salt water have had limited success in producing larger migrants with a better chance of survival in the sea.

The great ocean mortality of small salmon is being carefully examined to determine when it occurs and the cause, whether predators or disease, and what can be done to reduce this loss.

In the international field, some unique research has been developed to identify salmon of North American and Asian origin on the high seas. Using age analysis, structural characters, blood typing, and tagging, scientists have demonstrated the migration, distribution, and abundance of North American stocks of salmon in the ocean. As a result of this research, the United States has been able to argue firmly against indiscriminate high seas fishing for salmon by any foreign nation. An unrestricted high seas salmon fishery invariably takes immature fish and also removes mature salmon before they reach their home stream management area. Thus, an entire run of salmon specific to one particular home stream could be seriously depleted.

There follows some statistics on Pacific salmon and a list of bibliographic references for the reader who wishes more detailed information.

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Shipboard measurement of salmon.

Biologist removing scale for examination.

Fishery scientist taking a blood sample.

Technologist counting scales along lateral line.

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